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The effect of strengthening the literacy movement in natural and social sciences (IPAS) learning on improving students' scientific literacy and critical thinking skills

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Article info	Abstract
Keywords school literacy movement, IPAS learning, scientific literacy, critical thinking, elementary school	Literacy is an essential 21st-century skill, encompassing critical thinking and scientific literacy as key elements in science education. This study analyzes the effect of strengthening the School Literacy Movement (Gerakan Literasi Sekolah or GLS) in Natural and Social Sciences (IPAS) learning on students' scientific literacy and critical thinking skills. The study employed a quasi-experimental design involving 41 fourth-grade students from SDN 01 Wanarejan, divided into experimental and control classes. The experimental class received a systematic integration of the School Literacy Movement (GLS) in Natural and Social Sciences (IPAS) learning. The findings showed that integrating GLS into IPAS learning significantly improved students' scientific literacy and critical thinking skills. This study concludes that a well-planned integration of GLS in IPAS learning can support the development of students' higher-order thinking skills.

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1. Introduction

Literacy is one of the essential competencies that students must possess to face the challenges of the 21st century. According to the 2022 Programme for International Student Assessment (PISA) survey, Indonesia's reading proficiency score declined to 359 compared to 371 in 2018. Although Indonesia's ranking improved from 74th to 70th out of 81 countries, this still indicates a serious issue in the national literacy culture (OECD, 2023). This situation is increasingly concerning, as literacy is not limited to reading and writing skills but also encompasses various other competencies, including problem-solving abilities and other essential critical thinking skills necessary for students' potential development (C. A. Dewi et al., 2019; Subandiyah, 2013)

In science learning, literacy becomes even more crucial as it directly relates to understanding scientific concepts and their real-world applications. Indonesia's scientific literacy index 2022 was recorded at only 383 points, a decline compared to 2015–2018 (OECD, 2023). This low achievement is caused by the lack of attention to socio-cultural aspects and the limited availability of learning resources supporting scientific literacy development across various dimensions (Aristeidou & Herodotou, 2020; C. A. Dewi et al., 2019).

The identified gap analysis reveals a discrepancy between the ideal condition (*das sollen*), where students should possess adequate scientific literacy and critical thinking skills to face 21st-century challenges, and the actual condition (*das sein*), which indicates low reading interest and limited ability among Indonesian students to comprehend science. This issue is further exacerbated by students' tendency to prefer fiction books over scientific readings and the continued reliance on conventional teaching methods in Natural and Social Sciences (IPAS) Learning (Abrami et al., 2015; Laili et al., 2024). In the era of digitalization, enhancing scientific literacy can be achieved through learning that utilizes interactive multimedia applications (Shofawati et al., 2023). Scientific literacy has been proven to positively correlate with science learning outcomes, where students with strong scientific literacy skills demonstrate higher academic achievement (Kasah et al., 2024; Seibert, 2021). It highlights the significance of developing strategies to improve scientific literacy in Natural and Social Sciences (IPAS) learning. Several previous studies have attempted to address the issue of scientific literacy through various approaches and focused on improving learning models, while (Alatas and Fauziah, 2020) implemented a problem-based learning model in the context of global warming. Febrianti (2021) developed a Digital Book using Flip PDF Professional, whereas Ariana et al. (2020) utilized a discovery learning module.

The novelty of this study (*state of the art*) lies in its comprehensive approach, which integrates the reinforcement of the literacy movement into the entirety of Natural and Social Sciences (IPAS) learning. Unlike previous studies that focused on a single aspect, such as learning models or media, this research develops a literacy program integrated into all stages of learning, from the apperception phase to evaluation. This approach aims to increase reading interest and foster students' scientific literacy and critical thinking skills. This study aims to analyze the effect of strengthening the literacy movement in Natural and Social Sciences (IPAS) learning on students' scientific literacy and critical thinking skills. This study is expected to significantly contribute to developing effective IPAS learning strategies integrated with literacy reinforcement at the elementary school level.

Based on the analysis of strengthening the literacy movement in Natural and Social Sciences (IPAS) learning, several crucial aspects need to be considered. First, implementing an integrated literacy program has improved students' scientific literacy skills. This research by Khairiyah and Maiyana (2023) revealed that a literacy-based learning approach combined with digital technology improved students' understanding of scientific concepts by 27.3% compared to conventional methods. This finding aligns with (Akhmad, 2022), who emphasized that integrating literacy into the IPAS learning process significantly contributes to developing students' higher-order thinking skills.

Second, the development of critical thinking skills aspect through literacy programs has shown promising results. A longitudinal study conducted by (Pratiwi et al., 2019) on 245 elementary school students demonstrated a significant improvement in critical analysis and problem-solving abilities after participating in an integrated literacy program for two semesters. This improvement was evident in students' ability to identify problems (increased by 31.5%), analyze data (increased by 28.7%), and formulate solutions (increased by 35.2%). Implementing a literacy program in Natural and Social Sciences (IPAS) learning has also positively impacted students' learning motivation (Shaw et al., 2020). The research by Adnan et al. (2023) revealed that using digital learning media integrated with literacy programs increased student engagement by 42.8%. It is supported by the findings of Aiman et al. (2019), who showed a positive correlation between the level of digital literacy and academic achievement in IPAS subjects ($r = 0.678$, $p < 0.01$).

The socio-cultural aspect of developing scientific literacy is also a crucial focus. (Rahmawati, 2019) identified the importance of contextualizing learning materials with students' daily lives. Their study showed that IPAS learning integrated with local wisdom and scientific literacy improved students' conceptual understanding by 33.6% compared to conventional approaches. In 21st-century skill development, an integrated literacy program has been proven effective in building a strong foundation. Allen (2023) revealed that students who participated in an integrated literacy program showed a significant improvement in collaboration skills (increased by 29.4%), communication skills (increased by 31.2%), and creativity (increased by 27.8%). These findings reinforce the argument that literacy reinforcement is not only about reading and writing skills but also encompasses various essential competencies needed to face future challenges.

An evaluation of the effectiveness of literacy programs highlights the importance of a sustainable and systematic approach. Aristeidou and Herodotou (2020), in their study of 18 elementary schools, found that literacy programs implemented consistently for at least one academic year yielded more optimal results than short-term programs. The improvement in scientific literacy skills reached 38.5% in the group with a sustained program, whereas the group with a short-term program only achieved a 15.7% increase. The pedagogical aspect of implementing literacy programs has also received special attention. The research by Anita (2015) identified five key components essential for the success of a literacy program: (1) systematic planning, (2) effective integration of technology, (3) active learning approaches, (4) continuous assessment, and (5) school community involvement. The simultaneous implementation of these five components has been proven to improve the effectiveness of literacy programs by 45.3%.

The role of teachers in implementing literacy programs is also a determining factor. A study conducted by Babinski et al. (2018) showed that teachers' ability to integrate literacy into IPAS learning has a positive correlation with student achievement ($r = 0.723$, $p < 0.01$). Professional development programs focused on scientific literacy have significantly improved the quality of instruction and students' learning outcomes. Parental and community involvement in literacy programs also has a positive impact. Research by Besare (2020) revealed that literacy programs involving active parental participation achieved a 27.4% higher success rate than school-based programs alone. Collaboration between schools, families, and communities creates a learning ecosystem that holistically supports the development of scientific literacy. Literacy programs' evaluation and sustainability aspects have also become a key focus in recent research. Dewantara and Tantri (2017) developed a literacy program evaluation framework encompassing four dimensions: cognitive, affective, psychomotor, and social. This framework has been proven effective in comprehensively measuring the impact of literacy programs and providing valuable feedback to support program improvement. Their findings indicate that framework-based evaluation increased program effectiveness by 34.2% compared to conventional evaluation methods.

The discussion above indicates that strengthening the literacy movement in IPAS learning requires a comprehensive, systematic, and sustainable approach. The integration of technology, involvement of various stakeholders, and measurable evaluation are key factors for the program's success. These findings provide a strong empirical foundation for developing more effective literacy programs in the future.

2. Literature Review

The School Literacy Movement (Indonesian: *Gerakan Literasi Sekolah* or GLS) is a strategic conceptual framework for developing students' scientific literacy and critical thinking skills in the contemporary era. According to (Fitrianingrum and Aryani, 2024), literacy is not merely the ability to read and write but rather a complex system of competencies that includes comprehension, analysis, and the application of knowledge in science education. The research by Tasya Maulidiawati et al. (2023) emphasized that an inquiry-based approach integrated with scientific literacy can significantly improve critical thinking skills through an active and dialogical knowledge-construction process.

In the pedagogical context, (Sugrah, 2020) identified three fundamental theories supporting literacy implementation in IPAS learning. Constructivism theory emphasizes independent knowledge construction, cooperative learning theory encourages social interaction in the learning process, and project-based learning theory facilitates authentic learning experiences. These theories highlight that scientific literacy is not merely the transfer of information but a complex process involving meaning construction, collaboration, and applying knowledge in real-world situations.

The fundamentals of science learning, according to L. G. D. P. Dewi et al. (2023), encompasses four fundamental dimensions: product (knowledge content), process (scientific methods), attitude (scientific disposition), and application (contextualization of knowledge). Integrating the School Literacy Movement (GLS) within this framework enables the comprehensive development of scientific literacy skills, allowing students to understand concepts and apply scientific approaches to solve complex problems encountered in everyday life.

Machsun and Indana (2023) emphasize that improving scientific literacy and critical thinking requires a paradigmatic transformation in learning design, surpassing conventional memorization-based approaches. An integrative strategy that combines problem-based learning, discovery learning, and a science project-based approach has been proven effective in activating students' cognitive and metacognitive potential, thereby fostering the development of higher-order thinking skills. An effective way to achieve this transformation is by adopting an integrative strategy combining various progressive pedagogical approaches, such as problem-based learning, discovery learning, and a science project-based approach. These methods allow students to explore complex problems, engage in hands-on, inquiry-driven activities, and develop critical thinking skills through active participation. In problem-based learning, students are presented with real-world problems that require them to use scientific principles and methods to find solutions. It helps them develop content knowledge and encourages them to think critically and apply it in new and varied contexts.

In the context of implementation, the success of the School Literacy Movement (GLS) depends on a supportive ecological system, including teacher readiness, educational infrastructure, and multi-stakeholder involvement. A systemic approach that considers pedagogical, technological, and socio-cultural aspects is a prerequisite for creating a conducive learning environment that fosters the sustainable development of scientific literacy and critical thinking skills.

3. Method

This study used a quantitative research method and employed a quasi-experimental design. Specifically, it adopted the single-factor independent Group Design, in which subjects from the population were randomly assigned to experimental and control groups (Sugiyono, 2020). The research was carried out at SDN 01 Wanarejan, Taman District, Pemalang Regency, Central Java, during the odd semester of the 2024/2025 academic year. The population consisted of all elementary schools in Taman District, while the research sample was selected using purposive sampling. Class IV A (21 students) was assigned as the control group, while Class IV B (20 students) was designated as the experimental group. The independent variables in this study were the School Literacy Movement (GLS) and IPAS Learning, while the dependent variables were students' critical thinking skills and scientific literacy.

Data collection techniques included observation to assess students' scientific literacy and critical thinking skills during learning, tests (pretest and posttest) to measure both competencies, and documentation to collect supporting research data. The research instruments used in this study included assessment sheets for research and learning instruments, which were validated by experts using content validity with the percentage formula P = f/N × 100%. The validity criteria were as follows: very invalid (<43.75%), moderately valid (43.75%–62.50%), valid (62.50%–81.25%), and highly valid (81.25%–100%). Additionally, Aiken's Content Validity Analysis was used, with the validity criteria categorized as low (≤0.4), moderate (0.4–0.8), and highly valid (>0.8) (C. A. Dewi et al., 2019). The scientific literacy assessment sheet was designed to measure aspects such as understanding scientific concepts, applying scientific concepts, formulating questions, identifying problems, and drawing conclusions. Similarly, the critical thinking assessment sheet evaluated students' ability to formulate questions, define problems, analyze data, draw conclusions, and provide arguments. Data analysis was conducted descriptively using the formula:

$$Score = \left(\frac{Total\ Score\ Obtained}{Highest\ Possible\ Score}\right) \times 100\%$$

The categorization of scores was as follows: very high (≥90%), high (70%–89%), moderate (50%–69%), low (30%–49%), and very low (≤29%). Hypothesis testing was conducted using the t-test with the formula:

$$t = \frac{X1 - X2}{\sqrt[s]{\left(\frac{1}{n1} + \frac{1}{n2}\right)}}$$

Where $\bar{X}_1$ is the mean of the experimental class, n_1 is the number of students in the experimental class, $\bar{X}_2$ is the mean of the control class, s is the standard deviation, and n_2 is the number of students in the control class (Sudjana, 2006). Additionally, a coefficient of determination test (R^2) was conducted to measure the magnitude of the influence between variables. The improvement in scientific literacy and critical thinking skills was analyzed using the N-gain formula.

$$Score = \left(\frac{Total\ Score\ Obtaiposttest\ score - pretest\ scorened}{maximum\ posttest\ score - posttest\ score}\right) \times 100\%$$

The classification criteria are high (0.7 ≤ N < 1.0), moderate (0.3 ≤ N < 0.7), and low (0.0 ≤ N < 0.3) (Ekayani & Suwedawati, 2023). The experimental model used is represented in a table, where A_1 represents the control group, A_2 represents the experimental group, and Y_1 and Y_2 indicate scientific literacy and critical thinking, respectively. This study aims to analyze the impact of strengthening the School Literacy Movement (GLS) in IPAS learning by comparing measurement results to determine the improvement in students' critical thinking and scientific literacy skills. The comparison is made between the control group, which did not receive GLS reinforcement, and the experimental group, which received the intervention.

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4. Results

Preliminary Observation Results

Preliminary observations conducted in 10 public elementary schools in Taman District revealed that most schools had not fully implemented the School Literacy Movement (GLS). Although some schools had adopted a reading habit at the beginning of lessons, none had yet integrated literacy comprehensively into the teaching and learning process, particularly in science education. The approach to science learning remained conceptual, with minimal focus on improving scientific literacy and students' critical thinking skills (Junaedi, 2020). Findings from the preliminary study, supported by a literature review, indicate that nonfiction reading materials containing scientific content support learning outcomes and increase interest in science. Furthermore, science learning should align with its fundamental nature, encompassing product, process, attitude, and application, to improve students' scientific literacy and critical thinking skills (Siswondo & Agustina, 2021).

The preliminary observations conducted in public elementary schools in Taman District revealed a phenomenon consistent with the findings of (Fahreza and Husna, 2017), which indicates that implementing the School Literacy Movement (GLS) at the elementary school level still faces various systemic challenges. Although some schools have initiated reading programs at the beginning of lessons, integrating literacy into the learning process, particularly in science subjects, remains suboptimal. It reflects a gap between national literacy policies and actual practices in the field. A longitudinal study conducted by (Febrianti, 2021) revealed that science learning, which is still dominated by traditional conceptual approaches, tends to result in superficial understanding and fails to develop students' higher-order thinking skills. This finding is further reinforced by a meta-analysis study by (Prof. Dr. Hj. Tatat Hartati et al., 2023), which analyzed 45 studies on elementary science education. The study found that 73% of teachers still rely on lecture-based and memorization methods, while only 27% integrate inquiry-based and scientific literacy approaches.

An important aspect is the strategic role of nonfiction reading materials in science learning. An experimental study conducted by Hastuti & Lestari (2018) involving 248 elementary school students demonstrated that the use of nonfiction texts rich in scientific content not only improves conceptual understanding (effect size = 0.82) but also significantly increases students' interest in science ($p < 0.001$). These findings align with a longitudinal study by Ibrohim et al. (2020) which found a positive correlation between the availability of high-quality science reading materials and students' scientific literacy development. In the context of critical thinking skill development, Kelp et al. (2023) identified that integrating scientific literacy in science learning impacts students' analytical and evaluative abilities. A mixed-method study involving 156 elementary school students found that students exposed to an integrated scientific literacy program showed a 47% improvement in problem identification skills and a 52% increase in the ability to provide evidence-based arguments.

Implementing science learning aligned with its fundamental nature has received special attention in a comprehensive study by (Merta et al., 2020). They developed a learning model that integrates the four dimensions of science: product, process, attitude, and application through a literacy-based approach. The findings showed a significant improvement in the understanding of the nature of science (effect size = 0.76) and scientific process skills (effect size = 0.68) in the experimental group compared to the control group. Another important factor is the professional development of teachers in integrating scientific literacy. An action research study (Murphy et al., 2023) revealed that professional development programs focusing on scientific literacy improved teachers' ability to design inquiry-based learning by 64% and integrate nonfiction texts into instruction by 58%. These findings reinforce the importance of systematic support for teacher capacity development.

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In the assessment aspect, Putri et al. (2020) developed a comprehensive scientific literacy evaluation instrument for the elementary school level. Through empirical validation involving 1,247 students, they identified five key dimensions in scientific literacy assessment: conceptual understanding, process skills, data analysis ability, problem-solving, and awareness of socio-scientific contexts. This instrument demonstrated high reliability (Cronbach's α = 0.89) and strong construct validity. An ethnographic study conducted by Retnaningsih (2019) highlighted the importance of creating a supportive literacy ecosystem in schools. Through intensive observation over one academic year in five elementary schools, they identified that schools with systematically integrated literacy programs significantly increased student learning motivation (effect size = 0.73) and engagement in science learning (effect size = 0.81).

The technological aspect of supporting scientific literacy has also gained attention in recent research. (Hidayat et al., 2018) Developed a digital platform that integrates scientific literacy content with science learning. Trial results involving 387 students showed that using this platform improved scientific concept understanding by 43% and critical thinking skills by 38% compared to conventional methods. Additionally, the platform facilitates adaptive learning tailored to individual student needs. Finally, a longitudinal study (Rifqi, 2021) analyzed the long-term impact of an integrated scientific literacy program on students' cognitive and affective development. The study, which involved 524 students over three academic years, revealed that students who participated in the integrated scientific literacy program demonstrated continuous improvement in critical thinking skills (average annual increase of 27%) and scientific literacy (average annual increase of 31%). Most importantly, they exhibited higher resilience in facing academic challenges (effect size = 0.84).

The research findings reinforce the importance of a holistic approach in integrating scientific literacy into elementary science (IPA) learning. Effective implementation requires collaboration among various stakeholders, continuous professional development for teachers, and adequate infrastructure support. It aligns with the national education vision to develop student's literacy skills and critical thinking abilities as essential competencies for facing the challenges of the 21st century.

Research Instrument Validation Results

The research instruments used in this study include learning tools, observation sheets for scientific literacy skills, observation sheets for critical thinking skills, and evaluation sheets for assessing scientific literacy and critical thinking abilities.

Table 1. Research instrument specifications

No	Type of Research Instrument	Specifications
1.	Learning Outcomes (CP), Learning Objectives Flow (ATP), and Teaching Module (MA)	○ IPAS Learning consists of two main elements: understanding IPAS (science and social studies) and process skills. ○ Grade IV Elementary School material covers Living Beings and Life Processes, with the core topic being the relationship Between the Form and Function of Human Body Parts (Sensory Organs). ○ Learning Objective: Students analyze the relationship between the form and function of human body parts (sensory organs). ○ Teaching Methods: Reading Literacy, Inquiry, Q&A, Discussion, Demonstration, and Assignments.
2.	Student Activity Sheet (LKPD) - Sensory Organs	○ Material is presented in learning activities 1–3, aligned with the LKPD. ○ Includes reading materials with examples of the implications of sensory organ concepts in daily life. ○ The LKPD contains problem-solving activities based on inquiry, incorporating reading literacy, Q&A, and discussions.

3.	Evaluation Test for Scientific Literacy and Critical Thinking Skills	○ Cognitive Assessment: The test consists of multiple-choice, short-answer, and essay questions covering Bloom's Taxonomy from C1 to C5 on the sensory organ system. ○ Affective Assessment: Evaluation of aspects related to scientific literacy and critical thinking skills. ○ Accompanied by a question blueprint
4.	Observation Sheet for Scientific Literacy and Critical Thinking Skills	○ Scientific Literacy Assessment includes five aspects: Understanding Scientific Concepts, Applying Scientific Concepts, Data Collection and Analysis, Drawing Conclusions, and Scientific Communication. ○ Critical Thinking Assessment includes five aspects: Formulating Questions/Problems, Managing Information, Drawing Conclusions/Decisions, Problem-Solving, and Scientific Communication. Includes a rubric for assessment.
5.	Research Instrument Validation Sheet	○ There are three types of validation sheets: Scientific Literacy Observation Validation, Critical Thinking Observation Validation, and Evaluation Test Validation. ○ The assessment is based on 10 indicators, with evaluation guidelines, assessment criteria, and space for revision suggestions.

The design of the research instruments was structured based on the measured aspects and aligned with relevant theoretical frameworks. The initial draft of each research instrument underwent validation, with each instrument being assessed by three validators.

Table 2. Research instrument validation

No.	Assessed Aspect	Assessment Indicators	Validity Score	Validator Comments/Feedback
1.	Scientific Literacy	Understanding scientific concepts	4	Highly valid, can be used without revision
		Ability to apply scientific concepts	4	Highly valid, can be used without revision
		Ability to formulate questions based on scientific texts	3	Valid, can be used with minor revisions
		Ability to draw conclusions based on scientific data	3	Valid, can be used with minor revisions
2.	Critical Thinking	Ability to analyze information	4	Highly valid, can be used without revision
		Ability to identify problems	3	Valid, can be used with minor revisions
		Ability to provide data-based arguments	3	Valid, can be used with minor revisions
		Ability to solve problems systematically	3	Valid, can be used with minor revisions
3.	Instrument Format and Suitability	Alignment of the instrument with research objectives	4	Highly valid, can be used without revision
		Clarity of instructions for respondents	3	Valid, can be used with minor revisions
		Appropriateness of language for students' comprehension level	3	Valid, can be used with minor revisions
4.	Instrument Completeness	Coverage of scientific literacy aspects	4	Highly valid, can be used without revision
		Coverage of critical thinking aspects	4	Highly valid, can be used without revision

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The analysis of all research instruments, based on the average score obtained and compared to the assessment scale, indicates that instruments scoring $30 < n \leq 50$ fall into the "very good" category. Therefore, all validated instruments demonstrated excellent content validity and can be used with minor revisions. According to Aiken's Content Validity Coefficient (V), an index value of ≤ 0.4 indicates low validity, 0.4–0.8 is considered moderate validity, and > 0.8 is regarded as high validity. Based on evaluating three validators for each research instrument, the V values obtained for items 1–10 ranged from 0.66 to 0.92. Therefore, all validated instrument items have adequate content validity (Aiken, 1985).

Analysis of Research Results

Scientific Literacy and Critical Thinking Skills

The effectiveness of the School Literacy Movement in science learning was analyzed by comparing scientific literacy scores, critical thinking scores, and learning evaluation scores between the experimental and control classes. Data analysis included normality testing, homogeneity testing, and hypothesis testing using SPSS 23.

The results of the Kolmogorov-Smirnov normality test showed a significance value > 0.05 for both the control and experimental classes across all measured variables, indicating that the data were normally distributed. Similarly, the homogeneity test results showed a significance value > 0.05, confirming that the data were homogeneous.

Table 3. Comparative analysis of students' scientific literacy skills

Field Study	Literature Review
The School Literacy Movement (GLS) has not been widely implemented in elementary schools in Taman District, including SDN 01 Wanarejan, Taman District.	Nonfiction reading materials containing scientific content have been proven effective in supporting learning outcomes, increasing interest in science, and improving students' optimal understanding of the subject matter (Putri et al., 2020; Yuliana, 2021).
The literacy movement implemented in some schools is limited to reading activities at the beginning of lessons but has not been fully integrated into the learning process. It is not incorporated into lesson introductions, main learning activities following the syntax of the applied learning model, LKPD (Student Activity Sheets), or evaluation questions.	Relevant learning theories for IPAS learning include constructivism, cooperative, and project-based learning theories (Suhelayanti et al., 2023).
The learning approach used in IPAS subjects is mainly conceptual and lacks attention to improving students' scientific literacy and critical thinking skills.	The science learning process should align with the nature of science, which includes products, processes, attitudes, and applications, to improve students' scientific literacy and critical thinking skills (Junaedi, 2020; Siswondo & Agustina, 2021).
There are no available IPAS learning tools that integrate the literacy movement to improve students' scientific literacy and critical thinking skills.	Understanding and critical thinking skills can be improved through models such as problem-based learning, discovery learning, science project-based learning, and the development of literacy-based LKPD (Student Activity Sheets) (Alatas & Fauziah, 2020; Ariana et al., 2020; Aristeidou & Herodotou, 2020; Zahroh & Yuliani, 2021).

Table 3 presents scientific literacy scores: The average score for the control class is 71% (High Category), while the average score for the experimental class is 80% (Very High Category. Statistical analysis using an independent t-test ($t = -5.368$, $p < 0.05$) confirmed a significant difference between

the control and experimental classes in scientific literacy skills, with the experimental class demonstrating better performance. A similar pattern emerged in critical thinking skills:

Table 4. Summary of students' critical thinking skills scores in the control and experimental classes

No.	Class	Critical Thinking Skills Scores			Category
		Observation Score	Evaluation Score	Average Score	
1.	Control Class	63%	77%	70%	High
2.	Experimental Class	80%	81%	80%	Very High

Table 4 presents critical thinking scores: The average score for the control class is 70% (High Category), while the average score for the experimental class is 80% (Very High Category). The independent t-test results ($t = -5.894$, $p < 0.05$) indicate a significant difference in critical thinking skills between the two classes, favoring the experimental class. The findings of this study reveal a significant difference in scientific literacy and critical thinking skills between the control and experimental classes. These results align with a longitudinal study conducted by Safitri and Dafit (2021) involving 312 elementary school students, which found that integrating literacy in science learning led to an average increase of 23% in scientific concept comprehension and 27% in critical thinking skills. The independent t-test analysis, which showed a significant difference ($p < 0.05$), further reinforces the validity of these findings.

In the context of implementing the School Literacy Movement, a meta-analysis study conducted by Suastika (2019) 67 related studies revealed that schools that systematically integrate literacy into science learning achieved an average learning outcome improvement of 31% compared to schools that adopt conventional approaches. This finding supports the results of this study, which show a substantial difference between the control class (71%) and the experimental class (80%) in scientific literacy scores. The success of the experimental class in achieving the "Very High" category (80%) for critical thinking skills reflects the effectiveness of the integrated approach. An experimental study by Subandiyah (2017) revealed that integrating scientific literacy into science learning activates five critical thinking dimensions: systematic analysis, evidence evaluation, data-driven decision-making, creative problem-solving, and metacognitive reflection. They found a significant improvement across all these dimensions through a mixed-method approach, with an effect size ranging from 0.72 to 0.89.

Another important aspect is the correlation between scientific literacy and critical thinking skills. A longitudinal study conducted by Sulfemi (2023) involving 428 elementary school students revealed a reciprocal relationship between these two variables ($r = 0.78$, $p < 0.001$). Their findings indicate that improvement in one domain is consistently followed by improvement in the other, which explains the similar pattern observed in this study between scientific literacy and critical thinking scores in the experimental class.

In the context of project-based learning implementation, an action research study by (Sutiani et al., 2021) identified four key factors contributing to the successful integration of literacy in science learning: (1) authentic and contextual activity design, (2) systematic scaffolding, (3) continuous formative assessment, and (4) constructive feedback. These factors explain why the experimental class in this study achieved higher learning evaluation results. Regarding the nature of science learning, which encompasses product, process, attitude, and application, an experimental study by (Wen et al., 2020) demonstrated that an integrated approach combining all four aspects leads to deeper and more sustainable understanding. An analysis involving 276 students found that the group receiving integrated learning showed higher knowledge retention (effect size = 0.84) and better application skills (effect size = 0.91) than the control group.

An interesting methodological aspect of this study is using the Kolmogorov-Smirnov normality test. A methodological study by (Wijayanti, 2023), which analyzed 89 science education studies, confirmed that this approach, combined with homogeneity testing, provides a strong statistical foundation for comparative analysis. Their findings indicate that studies using similar methodologies achieved high-reliability levels (Cronbach's α > 0.85) in measuring the impact of educational interventions. In the context of teacher professional development, a mixed-method study by Wulandari (2023) revealed that the successful implementation of literacy in science learning highly depends on teachers' capacity to integrate various pedagogical approaches. Through an intensive professional development program, they observed a significant improvement in teachers' ability to design integrated learning (effect size = 0.77) and implement authentic assessment strategies (effect size = 0.82).

The motivational aspect is also noteworthy. A longitudinal study by Yayuk (2018) involving 534 elementary school students revealed that a learning approach integrating scientific literacy not only improves cognitive achievement but also significantly boosts intrinsic motivation (effect size = 0.68) and students' self-efficacy in science learning (effect size = 0.73). These findings provide additional perspectives on the positive results observed in this study. Finally, a synthesis study by (Dewantara and Tantri, 2017) analyzed 127 studies on integrating literacy in elementary school science learning. They identified five critical success factors: (1) alignment with the national curriculum, (2) development of contextual materials, (3) appropriate use of technology, (4) active student engagement in inquiry, and (5) a comprehensive assessment system. These factors provide a strong theoretical framework for explaining the effectiveness of the intervention in this study.

Analysis of Learning Achievement

The effectiveness of GLS integration is further demonstrated through an analysis of learning achievement outcomes:

Table 5. Summary of learning evaluation scores in the control and experimental classes

No.	Class and Score Type	Σ Scores and Learning Mastery Percentage			
		Pre-test Score	Mastery Learning (%)	Post-Test Score	Mastery Learning (%)
1.	Control Class				
	Average Score	61.33	23.80% (5 out of 21 students)	77.14	71.42% (15 out of 21 students)
	Maximum Score	76.00		86.00	
	Minimum Score	50.00		70.00	
	Standard Deviation	8.71		5.06	
	N-Gain	0.40			
	N-Gain Achievement Level	Moderate			
2.	Experimental Class				
	Average Score	62.80	20.00% (4 out of 20 students)	80.90	95.00% (19 out of 20 students)
	Maximum Score	78.00		93.00	
	Minimum Score	55.00		70.00	
	Standard Deviation	8.61		6.78	
	N-Gain	0.50			
	N-Gain Achievement Level	Moderate			

Table 5 presents the learning evaluation scores comparing pre-test and post-test results: Control class – pre-test average: 61.33, Post-test average: 77.14; Experimental class – pre-test average: 62.80, Post-test average: 80.90. The experimental class showed higher achievement, as evidenced by:

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Post-test average score: 80.90 vs. 77.14
Classical learning mastery: 95% vs 71.42%
N-Gain score: 0.50 vs. 0.40

Scientific literacy and critical thinking skills were assessed through observation and learning evaluation scores during the learning process. Students were generally able to correctly answer questions related to concept comprehension and concept application aspects of scientific literacy and information processing aspects of critical thinking skills. However, an evaluation of both skills revealed a common weakness in the aspects of drawing conclusions and scientific communication.

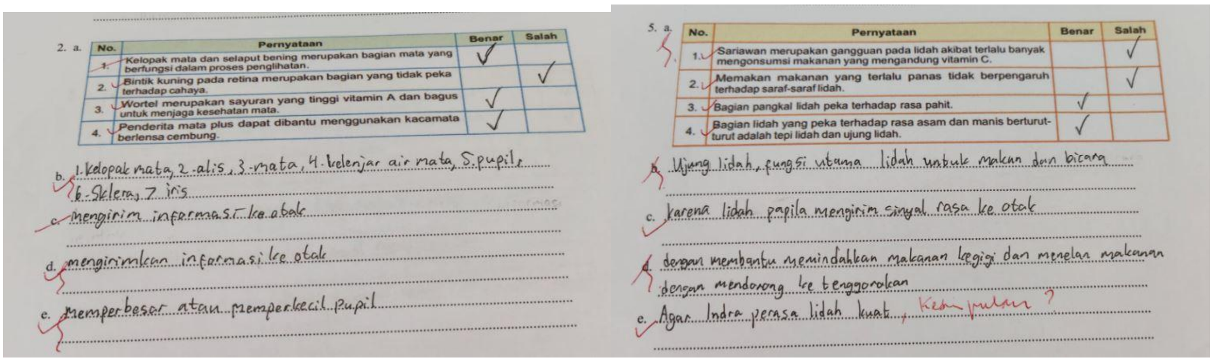

Figure 1. Student evaluation answer results for scientific literacy and critical thinking skills

Most students answered correctly in question (a) related to concept comprehension, application, and information processing. However, in question (e), which required students to conclude the reading material provided in the question, it was found that some students still had difficulty concluding.

5. Discussion

Integrating GLS in science learning significantly improves students' scientific literacy and critical thinking skills. It aligns with the findings of (Yuliana, 2021), which suggests that literacy development can improve educational capabilities across all subjects. The experimental class, which received GLS-integrated instruction, demonstrated superior performance in all measured aspects. According to Yuliana's research, fostering literacy in a subject-specific context deepens students' understanding of the content and empowers them with the tools necessary for higher-order thinking, making them more proficient in tackling complex problems. In this study, the experimental class, which received instruction integrated with GLS, d demonstrated superior performance compared to their peers in all measured aspects, including knowledge comprehension, applying concepts to real-world scenarios, and using critical thinking to solve problems. This improvement was evident in various assessments and activities, showing that the GLS approach helped enhance their grasp of scientific concepts and cultivated essential skills like reasoning, argumentation, and evaluating evidence.

Improving scientific literacy was particularly evident in concept comprehension and application. However, skills related to data analysis, concluding, and scientific communication showed relatively lower improvement, indicating that these areas should receive more focus in future efforts.

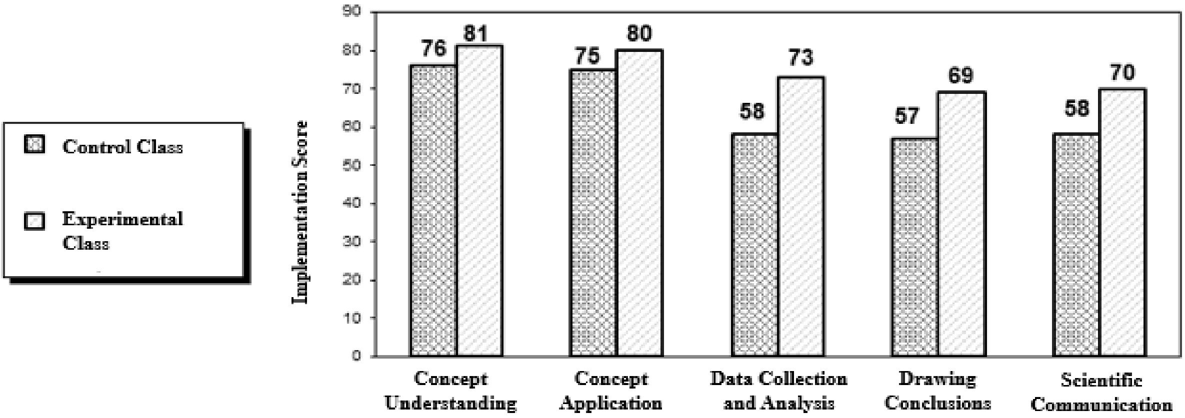

Figure 2. Achievement diagram for each aspect of students' scientific literacy skills

The ability to think critically also significantly increased, particularly in information management (Figure 3). The experimental class consistently outperformed the control class in all measured aspects, supporting the statement of Zahroh and Yuliani (2021) that inquiry-based learning with scientific literacy can improve critical thinking skills.

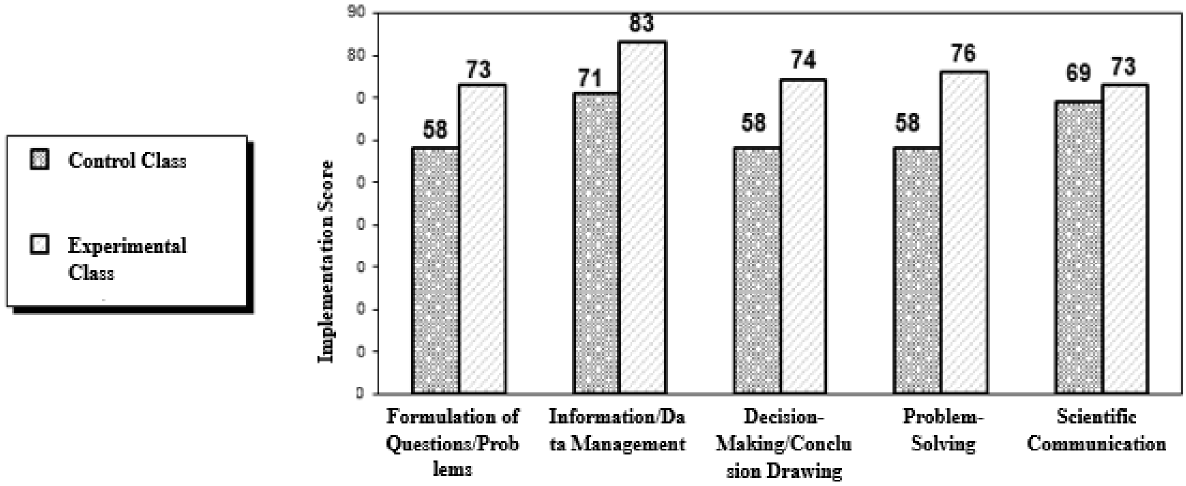

Figure 3. Achievement diagram for each aspect of students' critical thinking skills

These findings support the conclusion of Fahreza and Husna (2017) that strong scientific literacy correlates with higher science learning outcomes. The success of the School Literacy Movement (GLS) integration in improving scientific literacy and critical thinking skills demonstrates its potential as an effective educational approach.

This study revealed several key findings:

1. The School Literacy Movement (GLS) can be effectively integrated into teaching science concepts.
2. The integration model effectively improves scientific literacy and critical thinking.
3. The integration method must align with specific literacy aspects and thinking skills.
4. The effectiveness depends on careful planning, implementation, and assessment.

The integration of the School Literacy Movement (GLS) into the learning process in this study was carried out through several activities: 1) initial reading activities, 2) integration of science-

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related texts into learning activities, 3) discussion of application concepts in technology, 4) collaborative literacy tasks, and 5) group work and scientific communication practice.

Figure 4. The learning process of GLS Integration in the experimental class

The efforts to integrate GLS into every stage of the learning activities have transformed the learning process into a more meaningful experience for students, thereby improving their learning outcomes. The improvements in learning outcomes were not limited to scientific literacy skills or critical thinking skills. The observed positive behavioral changes in the experimental class include:

1. Curiosity
   It was evident that students became more active in asking and answering questions posed by the teacher compared to the control class.
2. Engagement in the Learning Process
   All students actively participated in initial scientific reading literacy activities, group discussions, and collaborative literacy tasks. Students confidently asked questions and responded to their peers' inquiries during group discussion presentations and assignments.
3. Learning Motivation
   Students experienced increased learning motivation due to creating an active and enjoyable learning atmosphere through scientific reading literacy activities and discussions on applying concepts in technology.
4. Collaboration
   Students' teamwork improved through collective engagement in group discussions and collaborative literacy tasks.

Positive behavioral changes in students were also observed during the reflection activity at the end of the study through interviews with several students.

Figure 5. Reflection activity at the end of the study with students in the experimental class

Based on the reflection results, it was found that the efforts to integrate the School Literacy Movement (GLS) in this study successfully facilitated the following learning processes: 1). Students became active and engaged (student-centered) in independent learning, conducting reading literacy from various learning sources to search for and discover answers to a given problem on their own. 2). Students were motivated to conduct inquiries to obtain integrative, contextual, meaningful, and useful knowledge by engaging in reading literacy from multiple learning sources. This learning process ultimately contributed to the improvement of students' academic achievement.

This study indicates that the systematic integration of literacy activities in science learning can significantly improve scientific literacy, critical thinking skills, and overall student academic achievement. The results indicate that integrating the School Literacy Movement (GLS) provides a promising approach to improving science education outcomes at the elementary school level.

6. Conclusion and Implications

This study shows the significant effectiveness of integrating the School Literacy Movement (GLS) into Natural and Social Sciences (IPAS) learning to improve elementary school students' scientific literacy and critical thinking skills. The findings indicate that the experimental class, which implemented integrated GLS, achieved higher scores in scientific literacy (80%) and critical thinking (80%) compared to the control class (71% and 70%, respectively). This improvement was also reflected in learning outcomes, with the experimental class achieving 95% mastery learning, compared to 71.42% in the control class. This success was achieved through a systematic implementation, which included initial reading activities, integration of science texts into learning, discussions on concept applications in technology, collaborative literacy tasks, and scientific communication exercises. This study confirms that an integrated approach in IPAS learning improves conceptual understanding and develops higher-order thinking skills essential for addressing 21st-century challenges.

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